**Momentum and Collisions**

**Question 1:**

aa. Momentum is a quantity that is determined by calculating \_\_\_\_.

a. **m·v** b. **m·v** c. **v** d. **m**

**Question 2:**

aa. A plot of force versus time is shown for the collision of a baseball with a baseball bat. The plot of force versus time demonstrates that \_\_\_\_\_. Select all that apply.

Force

Time

a. Force is a wave.

b. The force acting on the baseball changes its direction over the course of the collision.

c. The force acting on the baseball changes its value over the course of the collision.

d. The force acting upon the baseball has a constant value and a changing direction.

**Question 3:**

aa. The magnitude of the before- and after-collision momentum of two colliding objects is shown in the diagram below. The direction of the momentum is indicated by the arrows.



a. The change in momentum of the pink object (the one on the left in each diagram) is \_\_\_\_\_\_\_\_\_\_ kg·m/s. (Assign a negative value to all leftward momentum values.)

b. The change in momentum of the yellow object (the one on the right in each diagram) is \_\_\_\_\_\_\_\_\_\_ kg·m/s. (Assign a negative value to all leftward momentum values.)

c. Total system momentum is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (conserved, not conserved).

**Question 4:**

aa. A pitcher throws a baseball to the catcher. The catcher catches the ball and brings it to a stop. Ignoring the flight through the air, the baseball encounters two different impulses - the one imparted to it by the pitcher and the one imparted to it by the catcher. How do these two impulses compare?

a. The impulse provided to the ball by the pitcher is equal to that provided by the catcher.

b. The impulse provided to the ball by the pitcher is less than that provided by the catcher.

c. The impulse provided to the ball by the pitcher is greater than that provided by the catcher.

**Question 5:**

aa. Use a letter to fill in the three blanks in the following paragraph:

A 60-kg object is moving at 20 m/s when a force brings the object to rest in 0.050 seconds. If the same object moving at the same initial speed was brought to rest in 0.50 seconds, then the required force would be \_\_\_\_\_\_\_\_\_\_, the resulting impulse would be \_\_\_\_\_\_\_\_\_\_. and resulting momentum change would be \_\_\_\_\_\_\_\_\_\_.

a. one-half of the original value

b. one-tenth of the original value

c. two times the original value

d. ten times the original value

e. the same as the original value

f. None of these choices suitably fill in this blank.

**Question 6:**

aa. You are sitting at a baseball game when a foul ball comes in your direction. You prepare to catch it bare-handed. To catch it safely, you should \_\_\_\_\_.

a. move your hands toward the ball during the impact with it

b. move your hands in the same direction as the ball during the impact with it

c. hold your hands as still and steady as possible during the impact with it

d. forget about using your hands and take it right in the teeth

**Question 7:**

aa. This is safe because doing so makes the \_\_\_\_\_.

a. impulse experienced by your hands greater than it otherwise would be

b. momentum change of the ball less than it otherwise would be

c. collision time greater and the force less than it otherwise would be

d. impulse experienced by your hands less than it otherwise would be

**Question 8:**

aa. A 4.0-kg object is moving at 6.0 m/s and then encounters a 18-Newton resistive force over a duration of 0.20 seconds. The impulse (magnitude only) experienced by this object is \_\_\_\_\_\_\_\_\_ N· s.

a. 90 b. 28 c. 114 d. 1.5

e. 0.9 ab. 0.150 ac. 18 ad. 24

ae. 3.6 bc. 0.600 bd. 1.84

**Question 9:**

aa. In a collision, an object encounters a force that acts for some interval of time. The product of the average force and the time interval is known as \_\_\_\_\_.

a. mass b. force c. impulse

d. acceleration e. velocity change

**Question 10:**

aa. The unit N•s is most often thought of as a unit of \_\_\_\_\_\_ and the unit kg•m/s is most often thought of as a unit of \_\_\_\_\_. Choose the two terms which fill in the two blanks in their respective order.

a. force, mass b. force, velocity

c. impulse, energy d. force, momentum

e. energy, momentum ab. impulse, momentum

ac. momentum, velocity

**Question 11:**

aa. Which of the following has a greater momentum?

a. A picnic table at a park.

b. A hot dog at rest on a picnic table.

c. A fly buzzing towards your hot dog at a picnic.

**Question 12:**

aa. Total system momentum is expected to be conserved for any collision between objects that occurs in an *isolated system*. What are the two defining characteristics of an *isolated system*? Choose two.

a. The colliding objects do not exert pushes or pulls upon each other.

b. Each colliding object in the system encounters the same change in velocity.

c. The system of two or more objects does not gain or lose mass.

d. The net external force on each individual object of the system is zero.

e. The net external force on the system is zero.

**Question 13:**

aa. According to the **impulse-momentum theorem**, one can be certain that an object that encounters a \_\_\_\_\_ will also experience a large momentum change.

a. large force b. large collision c. large impulse d. large net force

**Question 14:**

aa. The law of conservation of momentum applies to any collision between two objects that occurs in an isolated system. Assuming that the collision between Object A and Object B occurs in an isolated system, which of the following statements are consistent with this law? Select all that apply.

a. Object A will not have its momentum altered during a collision.

b. Object A's momentum before the collision is the same as it is after the collision.

c. Object A will have the same momentum as Object B both before and after the collision.

d. The total momentum of Objects A and B will be the same before and after the collision.

e. The change in Object A's momentum will be equal and opposite to the change in Object B's momentum.

**Question 15:**

aa. In a collision, an object experiences an impulse. This impulse causes and is equal to the \_\_\_\_\_\_\_\_\_\_\_\_\_ of the object.

a. force b. velocity

c. momentum d. acceleration

e. velocity change ab. energy change

ac. momentum change

**Question 16:**

aa. Which one of the following statements is true of momentum?

a. Momentum is a scalar quantity.

b. Momentum is a vector quantity; the direction of the vector is downwards.

c. Momentum is a vector quantity; the direction of the vector is in whichever direction the object moves.

d. Momentum is a vector quantity; the direction of the vector depends on whether the object is slowing down or speeding up.

**Question 17:**

aa. In a collision, an object experiences an impulse. This impulse can be determined by \_\_\_\_. Choose the two ways in which the impulse can be determined.

a. dividing the force on the object by the mass of the object

b. multiplying the force on the object by the mass of the object

c. dividing the force on the object by the acceleration of the object

d. multiplying the mass of the object by the acceleration of the object

e. dividing the force on the object by the time over which the force acts

f. multiplying the mass of the object by the velocity change of the object

g. multiplying the force on the object by the time over which the force acts

h. dividing the momentum change of the object by the time over which this change occurs

**Question 18:**

aa. The magnitude of the before- and after-collision momentum of two colliding objects is shown in the diagram below. The direction of the momentum is indicated by the arrows.



a. The total momentum of the system **before the collision** is \_\_\_\_\_\_\_\_\_\_\_\_\_\_ kg•m/s, directed to the \_\_\_\_\_\_\_\_\_\_\_. (left, right).

b. The total momentum of the system **after the collision** is \_\_\_\_\_\_\_\_\_\_\_\_\_\_ kg·m/s, directed to the \_\_\_\_\_\_\_\_\_\_\_. (left, right).

c. Total system momentum is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (conserved, not conserved).

**Question 19:**

aa. The magnitude of the before- and after-collision momentum of two colliding objects is shown in the diagram below. The direction of the momentum is indicated by the arrows.



a. The total momentum of the system **before the collision** is \_\_\_\_\_\_\_\_\_\_\_\_\_\_ kg•m/s, directed to the \_\_\_\_\_\_\_\_\_\_\_. (left, right).

b. The total momentum of the system **after the collision** is \_\_\_\_\_\_\_\_\_\_\_\_\_\_ kg·m/s, directed to the \_\_\_\_\_\_\_\_\_\_\_. (left, right).

c. Total system momentum is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (conserved, not conserved).

**Question 20:**

aa. Two ice dancers are at rest on the ice, facing each other with their hands together. They push off on each other in order to set each other in motion. The subsequent momentum change (magnitude only) of the two skaters will be \_\_\_\_.

a. the same for each skater

b. greatest for the skater with the least mass

c. greatest for the skater with the most mass

d. greatest for the skater who pushes with the greatest force

e. greatest for the skater who is pushed upon with the greatest force

**Question 21:**

aa. If two objects collide within an isolated system, then \_\_\_\_\_.

a. one can be sure that the total system momentum is conserved

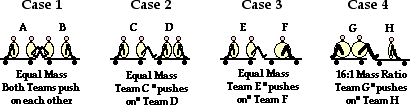
b. total system momentum will be conserved if they have the same mass

c. the objects will not change the amount of momentum which they possess

d. total system momentum will be conserved if they have the same initial velocity

**Questions 22-25:**

Students of varying mass are placed on large carts and deliver impulses to each other's carts, thus changing their momenta. In some cases, the carts are loaded with equal mass; in other cases they are unequal. In some cases, the students push off each other; in other cases, only one team does the pushing.



For each case, identify the team that ends up with the greatest momentum.

aa. In Case 1:

a. Team A has the greater momentum.

b. Team B has the greater momentum.

c. Each team has the same momentum.

aa. In Case 2:

a. Team C has the greater momentum.

b. Team D has the greater momentum.

c. Each team has the same momentum.

aa. In Case 3:

a. Team E has the greater momentum.

b. Team F has the greater momentum.

c. Each team has the same momentum.

aa. In Case 4:

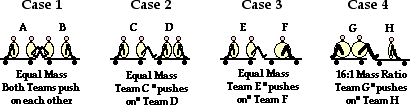
a. Team G has the greater momentum.

b. Team H has the greater momentum.

c. Each team has the same momentum.

**Questions 26-29:**

Students of varying mass are placed on large carts and deliver impulses to each other's carts, thus changing their momenta. In some cases, the carts are loaded with equal mass; in other cases they are unequal. In some cases, the students push off each other; in other cases, only one team does the pushing.



For each case, identify the team that ends up with the greatest speed.

aa. In Case 1:

a. Team A has the greater speed.

b. Team B has the greater speed.

c. Each team has the same speed.

aa. In Case 2:

a. Team C has the greater speed.

b. Team D has the greater speed.

c. Each team has the same speed.

aa. In Case 3:

a. Team E has the greater speed.

b. Team F has the greater speed.

c. Each team has the same speed.

aa. In Case 4:

a. Team G has the greater speed.

b. Team H has the greater speed.

c. Each team has the same speed.

**Question 30:**

aa. Complete the following statements by filling in the blanks with and A or B:

A. the same

B. a different

A home-made cannon is loaded with a tennis ball. Fuel is placed in the explosion chamber of the cannon and ignited. The subsequent explosion exerts forces on the tennis ball and the cannon, propelling them in opposite directions. During the explosion, the ball and the cannon experience \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ acceleration, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ force, \_\_\_\_ momentum change, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ impulse.

**Question 31:**

aa. Complete the following statements by filling in the blanks with and A, B or C:

A. greatest on/for cart A

B. greatest on/for cart B

C. the same on/for each cart

In a physics lab, two carts (labeled A and B) are at rest on a low-friction track. A spring-like plunger connects them. The springs are compressed and then suddenly released, exerting explosion-like forces on each of the two carts. Cart A is more massive than Cart B. During this 'explosion', the force is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; the impulse is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; the momentum change is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; and the acceleration is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**Questions 32-33:**

In a physics lab, two carts (labeled A and B) are at rest on a low-friction track. A spring-like plunger connects them. The springs are compressed and then suddenly released, exerting explosion-like forces on each of the two carts. Cart A is three times as massive as Cart B.

aa. During this 'explosion', the momentum change is \_\_\_\_.

a. the same for cart A as cart B

b. three times greater for cart A

c. three times greater for cart B

d. nine times greater on for cart B

e. nine times greater for cart A

aa. During this 'explosion', the velocity change is \_\_\_\_.

a. the same for cart A as cart B

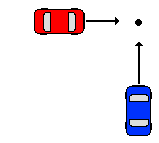
b. three times greater for cart A

c. three times greater for cart B

d. nine times greater on for cart B

e. nine times greater for cart A

**Questions 34-35:**

Two cars of identical mass collide at an intersection as shown in the diagram at the right. The red car is moving east at 12 m/s. The blue car is moving north at 16 m/s. The two cars entangle and move together after the collision.

aa. After the collision, the two cars will move in a direction that is \_\_\_\_\_.

a. more eastward than northward

b. as much northward as eastward

c. more northward than eastward

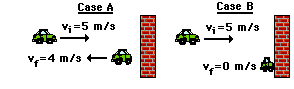
aa. If the red car was moving faster than 12 m/s (and the blue car was still moving at 16 m/s), then the direction that the two entangled cars moved after the collision would be \_\_\_\_\_.

a. unchanged

b. in a more eastward direction than in the previous question

c. in a more northward direction than in the previous question

**Questions 36-38:**

Consider the diagram at the right for the next three questions. The diagram depicts **Before** and **After** velocities of an 800-kg car in two different collisions with a wall. In case A, the car rebounds upon collision. In case B, the car hits the wall, crumples up and stops. Assume that the collision time for each collision is equal.

aa. In which case does the car experience the greatest momentum change?

a. Case A b. Case B  c. Both the same d. Insufficient information

aa. In which case does the car experience the greatest impulse?

a. Case A b. Case B  c. Both the same d. Insufficient information

aa. The impulse encountered by the **800-kg car** in case A has a magnitude of \_\_\_ N•s.

a. 0 b. 800 c. 3200 d. 4000

e. 7200 ab. Not enough information to determine.

**Question 39:**

aa. For each of the three pairs of objects described below, determine which object of the pair that has the greatest momentum.

First Pair:

a. GBS High School

b.A mosquito in flight

Second Pair:

a. A truck moving with the same speed.

b. Motorcycle moving at highway speed

Third Pair:

a. An object with mass **m/3** and velocity **2•v**

b. An object with mass **m** and velocity **v**

**Question 40:**

aa. **TRUE** or **FALSE**:

Object A is one-tenth the mass of object B. Therefore, object A could never have a greater momentum than object B.

a. True b. False

**Question 41:**

aa. **TRUE** or **FALSE**:

Momentum is a vector quantity; to fully describe it, one must indicate the direction.

a. True b. False

**Question 42:**

aa. **TRUE** or **FALSE**:

In a collision, an object experiences an **impulse**. An impulse is simply a phancy physics term for the word force.

a. True b. False

**Question 43:**

aa. **TRUE** or **FALSE**:

According to the law of momentum conservation, if a collision occurs in an isolated system, then any object involved in the collision will conserve its own momentum.

a. True b. False

**Question 44:**

aa. **TRUE** or **FALSE**:

All collisions involving impulses and momentum changes must result from actual contact interactions between the colliding objects.

a. True b. False

**Question 45:**

aa. **TRUE** or **FALSE**:

Suppose that a person pushes down on the Earth in order to jump into the air. The person gains upwards momentum but the Earth doesn't even budge. This is an example in which the law of momentum conservation does not hold since the Earth and person are not isolated.

a. True b. False

**Question 46:**

aa. **TRUE** or **FALSE**:

A different set of collision principles must be used when analyzing collisions of objects that occur in two dimensions.

a. True b. False

**Question 47:**

aa. An object encounters an impulse during a collision. This impulse depends \_\_\_\_\_\_\_\_\_\_ upon the force exerted on the object and \_\_\_\_\_\_\_\_\_\_ upon the time over which the force acts. (Choose the two words that best fill the blanks in their respective order.)

a. directly, inversely b. inversely, inversel

c. inversely, directly d. directly, directly

**Question 48:**

aa. A halfback (m = 60 kg), a tight end (m = 90 kg), and a lineman (m = 120 kg) are running down the football field. The lineman's velocity is 3 m/s. Consider their ticker tape patterns below.



Which player has the greatest momentum? If there is a tie, then select the two that tie.

a. halfback b. lineman c. tight end

**Question 49:**

aa. Before object A and object B collide, A has +16 units of momentum and B has +9 units of momentum. After the collision, if object A has +12 units of momentum, then object B must have \_\_\_\_\_\_\_\_\_\_\_\_ units of momentum. Assume an isolated system.

a. +5 b. +6.75 c. +9 d. +12

e. +13 ab. +21 ac. None of these

**Question 50:**

aa. Before object A and object B collide, A has +26 units of momentum and B has -14 units of momentum. After the collision, if object A has +8 units of momentum, then object B must have \_\_\_\_ units of momentum. Assume an isolated system.

a. +2 b. +4 c. +6 d. +12

e. +32 ab. +40 ac. -32 ad. -4

**Question 51:**

aa. Isolated systems are systems in which there are no \_\_\_\_\_ forces.

a. contact b. third-party c. friction d. internal

e. non-contact ab. gravity ac. isolated ad. external

**Calculation and Long Answer Questions**

**Question 52:**

aa. The momentum of a 1280-kg car is equal to the momentum of a 3850-kg truck traveling with a speed of 13.3 m/s. What is the speed (in m/s) of the car?

**Question 53:**

aa. An object with a mass of 16 kg moves with a constant velocity of 3.0 m/s for a time of 5.3 seconds. What is the momentum of the object?

**Question 54:**

aa. A 1.28-kg rubber ball moving with a speed of 5.36 m/s strikes a wall and rebounds with a speed of 1.65 m/s in the opposite direction. Determine the impulse (in N•s) encountered by the ball. **HINT:** The tennis ball *rebounds* in this collision, giving it a final velocity that is opposite in direction than its original velocity.

**Question 55:**

aa. A football player is running down the field with a momentum of 567 kg·m/s. The player encounters a force that causes him to stop in 1.4 seconds.

a. What is the final momentum of the player?

b. What is the change in momentum of the player? (Enter a positive value for an increase and a negative value for a decrease.)

c. What is the magnitude of the force that brings the player to a stop in this amount of time?

**Question 56:**

aa. An object at rest encounters an impulse of 72.8 N•s for 8.20 seconds. It then encounters a force of friction of 7.30 N for 3.64 seconds. For what time period (in s) must a final resistive force of 27.2 N be exerted in order to bring it to a final resting position?

**Question 57:**

aa. A force of 166 N acts on a 7.05-kg bowling ball for 0.39 seconds.

a. What is the bowling ball's change in momentum?

b. What is its change in velocity?

**Question 58:**

aa. Lee Mealone, a hermit, pushes a 12.0 kg boulder into the wall of his cave at a speed of 5.30 m/s, the boulder is brought to a stop in 1.29 seconds. What was the magnitude of the impulse (in N•s) imparted to the boulder?

**Question 59:**

aa. A 73.0-kg football player moving with a speed of 4.68 m/s collides mid-air with another player and gets knocked backwards. If the player experiences an average force of 3020 N over a time period of 0.234 s, then determine the final speed (in m/s) of the player.

**Question 60:**

aa. A 75.0-kg football player moving with a speed of 4.72 m/s collides mid-air with another player. If the player experiences a force of 8020 N over a time period of 0.272 s, then determine the momentum change (in kg•m/s) of the player.

**Question 61:**

aa. A 1.11 kg cannon is at rest. When ignited, it fires a 51.3 g tennis ball forward with a speed of 40.8 m/s. Determine the post-explosion speed (in m/s) of the cannon.

**Question 62:**

aa. A 1.50-kg cannon is mounted on top of a 2.00-kg cart and loaded with a 50.7-gram ball. The cannon, cart, and ball are moving forward with a speed of 1.22 m/s. The cannon is ignited and launches the 50.7-gram ball forward with a speed of 50.5 m/s. Determine the post-explosion velocity (in m/s) of the cannon and cart. Enter a negative value for a backward velocity and a positive value for an forward velocity.

**Question 63:**

aa. A 0.232-kg volleyball approaches Jessica with a velocity of 3.76 m/s. Jessica gives the ball a bump, sending it in the opposite direction with a speed of 2.46 m/s.

a. What is the change in momentum of the volleyball?

b. What average force does Jessica apply to the volleyball if the interaction time between her arms and the ball was 0.0247 seconds?

**Question 64:**

aa. A 0.142-kg baseball is moving at 31.9 m/s before being caught by the first baseman.

a. Find the loss in momentum of the ball.

b. If the ball is caught with the mitt held in a stationary position so that the ball stops in 0.049 seconds, then what is the average force exerted on the ball?

c. If, instead, the mitt is moving backward so that the ball takes 0.490 seconds to stop, what is the average force exerted by the mitt on the ball?

**Question 65:**

aa. Jack and Jill are ice skating on a circular pond with a 18.0-meter radius. (The pond is of course level, not inclined on a hill.) Jack has a mass of 71.7 kg and Jill has a mass of 51.7 kg. They stand facing each other at rest in the exact center of the pond. Jack and Jill then push off of each other and move in opposite directions at a constant speed towards the pond's edge.

a. If Jill moves with a speed of 4.42 m/s after the push-off, then what is Jack's speed?

b. How much time (after the push-off) will it take Jill to reach the pond's edge?

c. How much time (after the push-off) will it take Jack to reach the pond's edge?

**Question 66:**

aa. An object at rest encounters an impulse of 74.0 N•s for 8.20 seconds. It then encounters a force of friction of 8.53 N for 3.57 seconds. For what time period (in s) must a final resistive force of 35.0 be exerted in order to bring it to a final resting position?

**Question 67:**

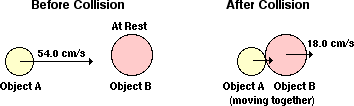
aa. A 11.8-kg object is in motion with a velocity of 4.02 m/s. It encounters an impulse of 45.7 N•s for 6.31 seconds in the same direction as its motion. What force (in N) would be required to stop it in 5.21 seconds?

**Question 68:**

aa. An object with mass of 3.20 kg encounters a force of 5.53 N for 5.0 seconds to accelerate it from rest. It then encounters an impulse of 24.2 N•s in the direction of motion for 6.5 seconds. Finally, a resistive force of 5.29 N is applied for 6.38 seconds. Determine the final momentum (in kg•m/s) of the object.

**Question 69:**

aa. The diagram below shows the before- and after-collision velocities of two objects involved in an *inelastic collision*.



Object A has a mass of 1.31 kg and object B has a mass of 2.62 kg. Use the mass and velocity values to determine the momentum of the objects before and after the collision. Enter all values in the table below. Finally, determine the total momentum of the system before and after the collision (last row) and the change in momentum of each individual object (last column).

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Before Collision**  **Momentum** **(kg·cm/s)** | **After Collision**  **Momentum** **(kg·cm/s)** | **Change in**  **Momentum** **(kg·cm/s)** |
| **Object A** |  |  |  |
| **Object B** |  |  |  |
| **System** |  |  |  |

**Conclusion**: In this collision between the two spheres, momentum is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (with no more than 2 percent deviation between the initial and the final amounts).

a. conserved b. not conserved

**Question 70:**

aa. A 115-kg red bumper car moving east at 1.70 m/s collides with a 150-kg blue car that is at rest. After the collision, the red car is moving east at 0.90 m/s and the blue car is moving east at 0.61 m/s. Use the coordinate axes with east as the positive direction and west as the negative direction and answer the following questions.

a. What is the momentum of the red bumper car before the collision?

b. What is the momentum of the blue bumper car before the collision?

c. What is the momentum of the red bumper car after the collision?

d. What is the momentum of the blue bumper car after the collision?

e. What is the total momentum of the two bumper cars before the collision?

f. What is the total momentum of the two bumper cars after the collision?

g. What is the change in momentum of the red bumper car?

(Note: A negative value indicates a loss of momentum.)

h. What is the change in momentum of the blue bumper car?

(Note: A negative value indicates a loss of momentum.)

i. In this collision between the red and the blue bumper cars, momentum is \_\_\_\_\_\_\_\_\_\_\_\_ (with no more than 2 percent deviation between the initial and the final amounts).

a. conserved b. not conserved

**Question 71:**

aa. Marble C, with a mass of 10.8 g, moves a a speed of 24.4 cm/s. It collides with marble D, with mass of 21.6 g, moving at 12.2 cm/s in the same direction. After the collision, marble C travels with a speed of 8.13 cm/s in the original direction.

a. Calculate the momenta of the two marbles before the collision.

**Marble C**: p = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g·cm/s

**Marble D**: p = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g·cm/s

b. Calculate the momentum of marble C after the collision. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g·cm/s

c. Assuming the collision occurs in an isolated system, what is the momentum of marble D after the collision. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g·cm/s

d. Determine the speed of marble D after the collision. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm/s

**Question 72:**

aa. Anna Litical and Noah Formula are doing The Cart and the Brick Lab. They drop a brick on a 2.47 kg cart moving at 23.1 cm/s. After the collision, the dropped brick and cart are moving together with a velocity of 11.1 cm/s. Determine the mass (in kg) of the dropped brick.

**Question 73:**

aa. A 7.02-kg bowling ball collides head-on with a 1.04-kg bowling pin. The pin flies forward with a speed of 2.63 m/s. If the ball continues forward with a speed of 1.22 m/s, what was the initial speed (in m/s) of the ball?

**Question 74:**

aa. A 90.1-kg fullback moving east with a speed of 4.61 m/s is *hit* by a 90.5-kg opponent moving north with a speed of 3.16 m/s. If the collision is perfectly inelastic, calculate the speed (in m/s) of the 90.1-kg fullback just after the *hit*.

**Question 75:**

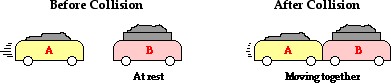
aa. A blue bumper car at an amusement park ride traveling at 3.01 m/s collides with an identical-mass green car that is at rest. This green car moves forward with a speed of 1.07 m/s. What is the velocity (in m/s) of the blue car after the collision?

**Question 76:**

aa. A 64.6-kg boy and a 49.1-kg girl, both wearing skates face each other at rest on a skating rink. The boy pushes the girl, sending her eastward with a speed of 3.57 m/s. Determine the subsequent speed (in m/s) of the boy. (Neglect friction.)

**Question 77:**

aa. The diagram below portrays two carts (cart **A** and cart **B**) involved in an *inelastic collision*.

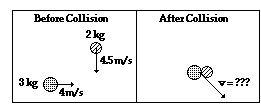


Cart A has a mass of 1.40 kg and is initially moving at 5.72 cm/s. Cart B has a mass of 2.16 kg and is initially at rest. After the collision the two carts stick together and move across the track at the same speed. Assume that the collision occurs in an isolated system and calculate the post-collision velocity of the two carts (in cm/s).

Cart A velocity (after the collision) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm/s

Cart B velocity (after the collision) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm/s

**Questions 78-81:**

The diagram at the right shows a 3 kg object moving at 4.0 m/s, colliding with a 2 kg object moving at 4.5 m/s. The collision is inelastic; the objects stick together and move with the same speed in the same direction. Use the diagram and information and principles of 2D collisions to answer the next four questions.

aa. The magnitude of the before-collision momentum of the system is \_\_\_\_\_ kg•m/s.

a. 3 b. 9 c. 12 d. 15

e. 20 ab. 21 ac. 42.5 ad. impossible to tell

aa. After the collision, the two objects would be moving \_\_\_\_\_\_.

a. exactly southeast (45° S of E) b. more eastward than southward

c. more southward than eastward d. impossible to tell with this little info

aa. The magnitude of the after-collision momentum of the system is \_\_\_\_\_ kg•m/s.

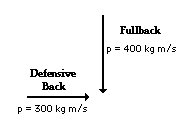
a. 3 b. 9 c. 12 d. 15

e. 20 ab. 21 ac. 42.5 ad. impossible to tell

aa. The after-collision velocity of the two objects is \_\_\_\_\_ m/s

a. 1.2 b. 3.0 c. 4.0 d. 4.2

e. 4.25 ab. 4.5 ac. 6.02 ad. 8.5



**Questions 82-85:**

A fullback (90 kg) and a defensive back (70 kg) collide in mid-air. The momenta of the two players are shown at the right.

aa. Determine the total momentum of the system before the collision.

aa. Determine the total momentum of the system after the collision.

aa. The two players entangle and move together after the collision. Determine their speed.

aa. Determine the direction that the two players move after the collision.

**Question 86:**

aa. A fullback (86.0 kg) and a defensive back (81.6 kg) collide in mid-air. The fullback is moving south at 7.03 m/s. The defensive back is moving east at 8.71 m/s.

a. Determine the pre-collision momentum of the fullback.

b. Determine the pre-collision momentum of the defensive back.

c. Determine the total momentum of the system of two players before the collision.

d. Determine the total momentum of the system of two players after the collision.

e. If the two players entangle together and move at the same speed and direction after the collision, then determine the speed at which they move.